Automated control system for the process of managing the procurement of raw materials used in steel making

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***Abstract*— The article presents a solution to the important problem of developing an automated control system for the process of purchasing raw materials used in metallurgical production. The system is based on an integrated approach that offers the solution that enables the performance of two main tasks: identifying the optimal lot size ordering and selecting a qualified supplier.**

***Keywords*— selection of the supplier, identifying the optimal lot size ordering, automated control system.**

I. INTRODUCTION

Procurement managing is a complex inclusive process that begins with identifying raw materials and supplies needed to be purchased and finding information on suppliers and ends with monitoring and analyzing the quality of their conformance. The procurement process at all its steps implies collaborative work between company's divisions and departments involved. Insufficiently coordinated actions of participants in the procurement process or information gap between them leads to disruptions in supplies and additional operational costs.

Effective interaction between company's departments and all participants in the procurement process can be bettered significantly by means of introducing a business process flow that is automated from start to finish. The key advantage of this approach for a purchasing department is increasing the efficient functioning of procurement management.

Thus, this work was aimed at creating an automated control system intended to manage the procurement processes for raw materials and supplies used in the metallurgical production.

The subject of this study is the process of recordkeeping and analyzing purchases of raw and other materials for metallurgical productions, using the case of LLC Yurginsky Machine Engineering Plant

II. FORMULATING THE PROBLEM

We consider the process automation designed for purchasing raw materials and supplies using the example of LLC Yurginsky Machine Engineering Plant, which is a representative of the machine-building industry in Kuzbass.

LLL Yurginsky Machine Engineering Plant manufactures a full range of mining machinery for longwall faces and equipment for open pits and dressing plants.

The company's metallurgical production is an industrial complex of the full production cycle outfitted with modern production facilities. Metallurgical products are mainly electric furnace steels with specified chemical compositions.

The part of the metallurgical complex is a thermomechanical workshop providing a complete cycle of thermal processes: surface impregnation, including nitriding, carburizing, and thermal treatment, and processing of big sized forgings and tubes up to 12 m length.

With updated devices and special equipment, the in-house main laboratory carries out testing and controls parameters and heat treatment processes to prove the quality of metallurgical products.

To ensure the smooth operation of all divisions and manufacture of quality products, it is necessary to organize on time delivery of quality raw materials.

Basically, there are two main tasks required to be carried out: identifying the optimal lot size orders and selecting a qualified supplier.

The Competitive Purchasing Department performs a number of functions to support the proper operation of the company. Among the functions are receiving and examining bids from potential vendors followed by making a purchasing decision.

At present, the plant experiences a difficulty with the efficiency of material procurement. The solution to this task is extremely important for the enterprise because the stable and efficient operation of the entire enterprise depends on the quality of raw materials and supplies. In this context the issue becomes extremely urgent.

Proper performance of the procurement function for the enterprise is increasingly important. In this connection, the process of making a decision on purchases requires additional responsibility and justification. Making a wrong decision may cause rising more serious problems and have both direct and indirect negative impact on the entire production process.

Thus, an urgent task that requires an operative solution is the development of an integrated automated control system to perform the procurement of raw materials used in steelmaking in a controlled manner.

III. EXISTING APPROACHES TO SOLVING THE PROBLEM

In the literature, the designated issues are analyzed individually in the context of finding solutions. Methods for determining the optimal a purchase quantity and

methods for selecting the supplier are considered separately as well [1, 2].

The problems related to determining the optimal size of an order are dealt in a considerable number of works by both Russian and foreign authors to start with the classic works of J. Hadley and T. Whitin, modern works of D. Bowersox and D. Closs, and G. Brodetsky, T. Blazhenkova, A. Gadginsky, A. Dolgov, V. Dybskaya, E. Zaitsev, E. Koroleva, V. Lukinsky, Yu. Nerush, A. Parfenov, O. Prokhodenko, O. Protsenko, Yu. Ryzhikov, V. Sergeev, I. Sidorov, A. Tyapukhin, S. Uvarov, V. Shcherbakov.

All the existing methods for determining the optimal lot size of orders are aimed at answering two basic questions: when to place an order and what quantity.

The main methods include the models of economic order quantity, production order quantity, order quantity with safety stock, economic order quantity with volume discount, probabilistic inventory models with constant lead time, etc.

There are also many different processes used to facilitate identifying and evaluating the right supplier in performing procurement, which are successfully applied in practice.

The problems related to substantiation and formation of organizational and methodical aspects for evaluating and selecting the supplier of goods are discussed in works of such authors as A.Volkov, A.Yevsukova, A. Kofman, V. Lukinsky, E. Makarov, E.Okoleva, A. Posposhkov, etc.

The models and approaches targeted to select the supplier are often based on the DEA (Data Envelopment Analysis) method inclusing a data convolution analysis. Its application is described in detail by AtefehAmindoust [3], RuiminMa [4] and other authors. Possible applying and developing models based on the ANH (Analytic Hierarchy Process) method that processes analytic hierarchies are presented in works of ŽeljkoStević and Sreenivasulu Reddy [5, 6, 7]. The systems of fuzzy logic and artificial intelligence are widely used as well [8, 9].

Thus, it becomes obvious that two aspects of the problem pertaining to the procurement management of raw and other materials have been comprehensively studied [11, 12]. However, at the same time, it is equally obvious that these issues are interconnected and require an integrated approach to their solution, rather than an individual examination.

It is necessary to develop an integrated control system for purchasing management of materials and supplies intended to attain the following main tasks:

continuous monitoring and analysis of materials and supplies consumption, their flow in the production process;

Forming the need in materials and supplies for production on the basis of the first step;

Identifying the optimal purchase quantity based on the results of the first and second steps;

Record keeping the data on deliveries carried out by current suppliers with subsequent analyzing these data, i.e. evaluating and selecting qualified and reliable suppliers according to criteria based on historical data on their performance;

5. Updating the list of suppliers, taking into account the information received in the previous steps.

IV. AUTOMATED CONTROL SYSTEM

To solve the stipulated problems, a control system is proposed (Figure 1) that integrates the two software modules: the first module is applied for assessing the criticality and need for materials and supplies; the second is for evaluating the suppliers of raw materials and supplies.

The modules in the system break down into the four steps describing both processes.

Step (1): analysis of materials and supplies consumption. To perform the work during this stage, statistical methods for data analysis, variance analysis and predictive analysis are used to determine anticipating needs.

Step (2): identification of the optimal quantity for ordering. We use the modified Wilson formula:

$$Q = \frac{\overline{2 \times A \times S}}{I \times J}, \text{ where}$$

A is the delivery cost per unit;
S is the monthly requirement;
I is the coefficient in percentage of the delivery cost;
J is the unit cost.

Step (3): supplier evaluation. Suppliers are evaluated according to the author's criterion-referenced scoring methodology. The main criterion for this model is on time delivery.

According to the developed approach, a supplier is evaluated and assessed against the four main criteria: On Time Delivery, Period of Cooperation with the Company; Terms of Payment; Quality-to-Price Ratio.

This approach assumes different scoring scales for each criterion, two to six points. For example, potential supplies are scored for the criterion "On Time Delivery" as follows: less than an hour delay/on time weights 5 points; 1 to 3 hour delay - 4 points; 3 to 5 hour delay - 3 points; 5 to 7 hour delay - 2 points; 7 to 9 hour delay - 1 point; more than 9 hours - 0 points.

The score against the criterion "Period of Cooperation with the Company" is assigned as follows: no cooperation - 0 points; less than a year cooperation - 1 point; 1 to 2 year cooperation - 2 points; 2 to 3 year cooperation - 3 points; 3 to 4 year cooperation - 4 points; more than 4 years - 5 points.

The criterion "Terms of payment" gives 0 points for prepayment and 1 point for a possible delay of payment.

The criterion "Quality-to-Price Ratio" is calculated as the ratio of quality rating of the supplied material (1-very low, 2-low, 3-medium, 4-high, 5-very high) to the supplier’s price. The score for quality is set in case of accepting the material into production.

Thus, points assigned against each criterion are summed up to contribute the total score related to each supplier. Further, as a result of ranking these scores, the final rating of suppliers is obtained.

Step (4) - Updating the list of suppliers. Based on data obtained during the previous step, a rating of suppliers is formed, which is used for decision making and a current list of suppliers can be reviewed.

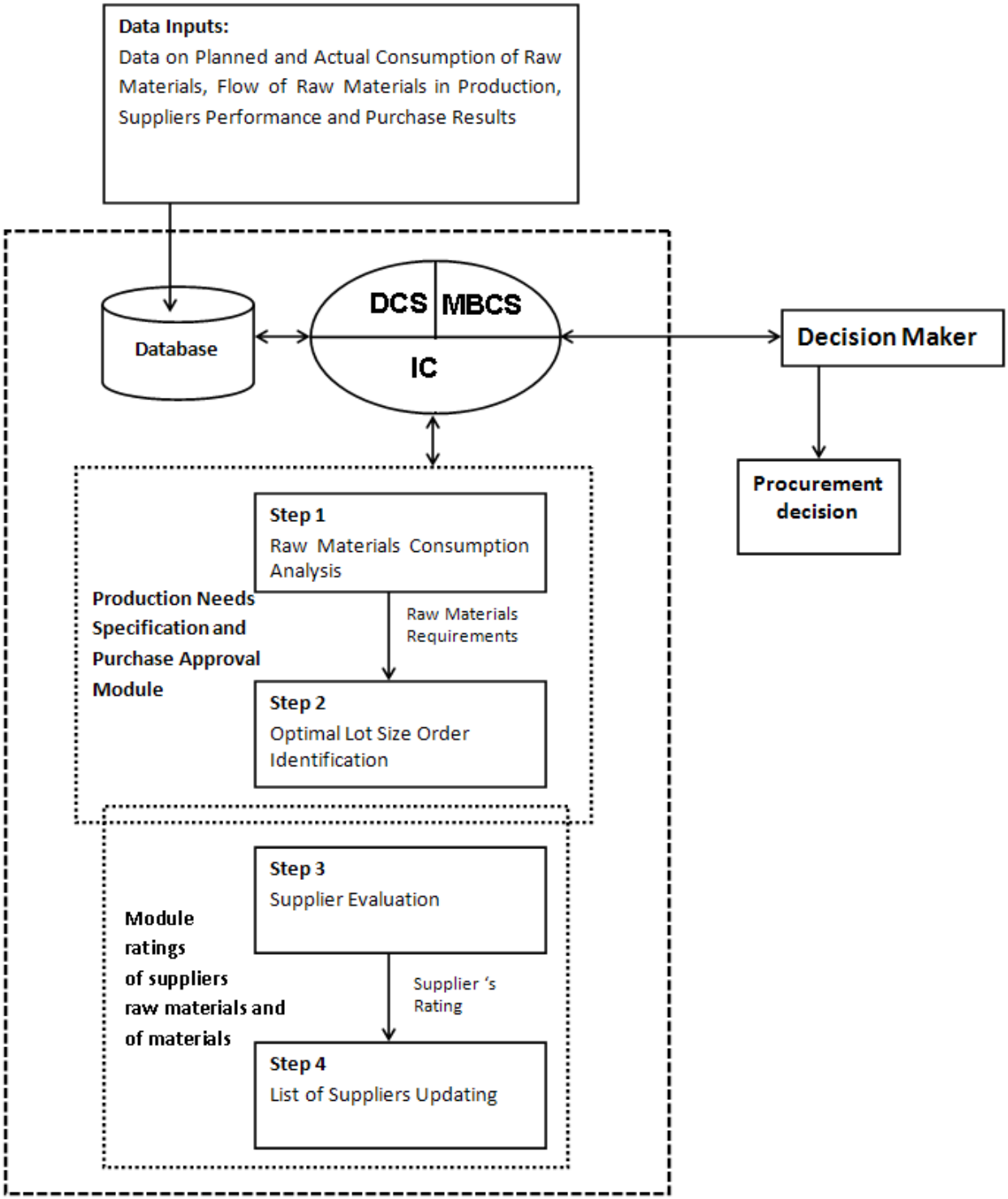

Figure 1 – Control System for Procurement Management of Raw Materials

Every module can be used autonomously to solve separate tasks, but all modules employ an interrelated set of data, and the results of calculations of a particular module are used as inputs for others. Each module has its own help system describing a principle of operation and models integrated into these modules.

The presented system makes it possible to increase the relevancy of decisions made in purchase managing when raw materials and supplies are required. This becomes possible due to a number of promising advantages and functions being implemented in the system that allow us in the decision-making process: to focus on analyzing statistical data and their dynamics, consider logic, intellect and intuition of a director and experts in this field, and identify the most significant indicators and factors attributed to analysis and evaluation.

The offered approach has received practical realization in the form of a computer-aided program operating on the platform 1C: the Enterprise 8.

Prior to the decision in favor of developing our own control system, we overviewed the software market to analyze the already existing products offering solutions with similar functions: SynExp: Competitive Procurement, 1C: Enterprise 8. Metallurgical Plant Management, Naumen GPMS - Procurement Management. However, this study concludes that in those systems there are no functions for analyzing purchasing procedures and recordkeeping plant's needs for raw materials and supplies, as well as for evaluating and assessing the reliability of suppliers, what leads to less efficient work on the organization of purchase and procurement activities at the enterprise.

In total, the system has three subsystems: purchase, raw materials and supplies, suppliers and vendors. Seven directories have been created for the information storage and correct operation of the system. Starting the operation in the system requires filling its databases.

Immediate information is saved in seven subject-oriented documents to update processes. The documents are designed to enter the execution of all business processes, ranging from a procurement request specifying the company's need for materials and subsequent records upon their actual delivery to handling of raw materials and inventory status records, as well as their availability for production.

The user's work to complete the system documents is minimized. All data is selected either from directory databases, or filled automatically when creating some documents based on others. So, for example, when creating a "Delivery" document, most of the information is extracted from the document "Procurement Request for Raw Materials and Supplies".

One of the important documents formed in the system is "Delivery Schedule". This document is created to classify suppliers according to types of materials and supplies, frequency of deliveries, with indicating delivery dates and volumes of shipments.

To make management decisions, the system provides for the compilation of reports as follows:

– Suppliers Report;
– "Best Suppliers" Report;
– Raw Materials Report;
– Contracts and Procurement Requests Report;
– Execution of Requests and Contracts Report;
– On Time Delivery Report;
– Purchase Average Cost Report;
– Price List Report;
– Production Turnover Report;
– "Calculation of the Optimal Quantity for Ordering" Report;
– Report for Planned and Actual Consumption of Raw Materials.

The main report is "Calculation of Optimal Quantity for Ordering". This report is used for calculating to specify an amount of raw materials required per month, the cost per unit of raw materials, delivery and storage costs per unit of raw materials. The optimal quantity of units for one order and the required number of such orders for a period are defined there as well.

On Time Delivery reporting is also of interest. The report presents a score assigned to suppliers against the criterion "On Time Delivery". The process of reporting results in the rating of suppliers by this criterion [10]. The evaluation is performed automatically based on the analysis of delivery documents, which record all non-conformances relative each delivery and each supplier. On time delivery is scored and attributes to evaluation in particular: the less the deviation against the planned delivery time, the higher the score. Then the score assigned against all criteria are summed up to contribute to a supplier rating that can be viewed using a special report [13].

The automated control system developed to manage the procurement of raw materials and materials was approved for operation testing and used by the Competitive Purchasing Department at LLC "Yurginsky Machine Engineering Plant", where it was highly valued by users. As a result of its pilot operation, it was established that the labor costs for organizing the procurement processes and their follow-up were reduced.

CONCLUSION

The automated control system proposed for the process of purchasing raw materials and supplies based on the platform 1C: Enterprise allows us to automate business processes related to the procurement activities of the enterprise with minimal initial costs in the shortest time possible. The control system for procurement management supports the entire procuring process ranging from applying and approving a procurement request to executing and reporting the results. In addition, the solution enables the management of procurement requests, delivery tracking as well as centralized storage of all related documents, including contracts and data on suppliers.

The developed system has scientific and practical significance.

The received scientific result is the approach to the evaluation of reliability of suppliers based on the author's criterion-referenced scoring method. The evaluation criteria were formulated after analyzing and summarizing the existing vendor evaluation systems

[14, 15]. It is the author's opinion that the criteria singled out in this work are crucial and can easily be taken into account or calculated as a result of automating the process of purchasing raw materials and supplies.

The practical result of developing the automated control system designed for the procurement process for raw materials and supplies is following:

1. The integrated approach to the procurement management for raw materials and supplies needed for metallurgical production in the form of a computer–aided program has been developed and practically implemented. The solutions to performing the two important tasks are combined in one management system: selecting a qualified supplier, identifying the optimal lot size for ordering.

2. Labor costs associated with organizing the procurement processes are decreased. The automated control system can significantly reduce labor costs. Automated paperwork and basic procedures simplify the procurement process management at the enterprise and provide means for decreasing a human mistake factor and avoiding a loss of data.

3. The modular principle is implemented. The control system for procurement management is built on a modular basis; a customer has an opportunity to find appropriate solutions in the context of the company's business processes.

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